

CHERMES OF COLORADO CONIFERS.

BY C. P. GILLETTE.

Genus *Chermes* comprises a small number of species that have not received the attention which is their due in this country. As an economic group they are of little importance so far as their injuries to forest trees are concerned, but some of the species become decidedly injurious to pines and spruces when used as shade trees in parks or private grounds.

The apterous females belonging to the genus are characterized by having broad oval bodies, very short three-jointed antennæ, short stout legs, short stout beaks with very long setæ, and a large number of glandular patches upon head, thorax and abdomen for the secretion of long waxen threads for protection. The winged females have short stout five-jointed antennæ, very broad heads, suckers at the distal ends of the tibiæ and strong anterior wings with two unbranched discoidal veins. Cornicles in both forms wanting.

The males, at least in the United States, are unknown. Reproduction is always by means of eggs which are attached in clusters to leaves or bark by means of silken threads.

Chermes cooleyi n. sp. (Plates I, II, III, IV.)

Chermes abietis L., Cooley, 34th Report Massachusetts Agricultural College, 1897; Author's separata, p. 4.

Chermes abietes L., Fletcher, Report of Entomologist and Botanist, Canada Central Experimental Farm, p. 190.

Chermes abietis L., Fletcher, *ibid.*, 1903, p. 167.

Chermes sibericus Chldky., Fletcher, *ibid.*, 1903, p. 167.

While I cannot be certain that the records by Dr. Fletcher given above refer to *Chermes cooleyi*, it is strongly probable that such is the case, as I have examined immature but fully formed galls that were kindly sent me from the Northwest by Dr. Fletcher, and also by Dr. Hopkins of the U. S. Bureau of Entomology, and they were in both instances large strong galls, exactly like the typical galls of *Chermes cooleyi*.

My studies of this species have been wholly in the West, and I have not seen either winged or wingless examples of the closely allied species *abietis* and *sibericus*. Dr. C. H. Fernald kindly sent me galls of *abietis*, however, from Massachusetts which seem quite unlike the galls of

cooleyi. The galls of *abietis* involve a comparatively small number of needles causing very large cells, in one of which thirty to fifty or more lice may develop, and the beginning of the gall formation is said to be caused by the punctures of the stem-mother at or close to a bud. The galls, it seems, seldom kill the terminal growth of the twig, and the number of eggs deposited by the winged female is given as "never much exceeding fifty," and the females are spoken of as though their eggs are freely deposited upon leaves of the same species of spruce that bears their galls. All these conditions are quite different in case of *Chermes cooleyi*, as may be seen by the account given below.

Chermes abietis is also described by Buckton and Cooley as having but one joint to the tarsus; but this is doubtless an error, as all the species I have studied have two joints, though the first is short and easily overlooked.

I sent specimens of both the galls and the lice of *Chermes cooleyi* to Dr. N. Cholodkowsky, of St. Petersburg, Russia, asking him if it were possible that this Western *Chermes* could be *abietis* or *sibericus*, and in his reply, written October 23, 1904, he said, "This is decidedly not *Chermes abietis*, nor is it *Chermes sibericus*, but a new species."

Life Habits.—The small hibernating form of this louse spends the fall and winter months upon the twigs of its host-plant, with its long setæ thrust into the crevices in the bark between the needles. The heavy winter skin is cast at Fort Collins about the middle of April, and in a day or two the white secretion again shows the location of the louse, which is always upon the under side of the twig.

The first eggs are deposited at Fort Collins about April 25, before the female has attained her maximum size. On May 3, 1906, three of the fifteen females examined were laying eggs, and the largest number found at one female was twelve. The white waxy threads completely hide both the eggs and the female at first, and serve doubtless as a protection to them (Plate I, figs, A, B, C). These white patches from a single female may measure four or five millimeters across and cover several hundred eggs. Counts of a few patches gave the following numbers: One female, 344 unhatched, 75 hatched; another, 561 unhatched, 0 hatched; two females together, 751 unhatched, 200 hatched, an average of 483. I have frequently counted four or five of these egg-masses within two inches of the end of a twig, and I have counted as many as fifteen females ovipositing on this length of stem. About May 20, before the hibernating females had finished laying their eggs, those that were first deposited began to hatch, and by May 25 the lice were hatching rapidly and locating at the bases of the tender

new leaves that were just beginning to show at the terminal buds. I have been unable to see that the punctures of the stem-mothers have any effect to produce the galls, which seems to be caused entirely by the irritation produced by the young lice inserting their beaks and sucking the sap at the bases of the young growing needles. In fact, only those needles enter into the formation of the gall that actually have lice located at their bases. It sometimes happens that only a few needles are attacked and these needles become swollen at their bases, while all the others on the new growth of the twig are normal; and it is not infrequent that a few of the needles of the new growth fail to have any lice locate in their axils, and these needles remain normal in form on a gall where all others are greatly swollen. It seems possible, however, that the puncture of the stem-mother may have some influence upon the formation of the gall, as I transferred hatching egg-masses in several instances to twigs where there was no egg-mass and in no case did a gall form or any of the lice live. I also transferred the eggs to tender new growths of red fir (*Pseudotsuga mucronata*), but none of the young hatching from the eggs became established upon the changed food plant.

The galls (Pls. I and II) develop with surprising rapidity, and are due to the thickening and lateral enlargement of the bases of the needles together with the enlarging of the stem. In color, the growing galls vary from light green to a dark purple. They are always terminal in position and kill the end of the twig, except when the lice attack the bases of a few needles only on one side of the new growth, leaving the others, including those at the end, to develop normally, and such galls are quite uncommon.

The size of the gall depends upon the vigor of the tree and the number of lice that are at hand to attack the new leaves. A weak growing twig cannot develop a large gall. Vigorous growing young silver spruces (*Picea parryana*) on the campus of the Colorado Agricultural College often develop galls that are $1\frac{3}{4}$ to 2 inches in length and $\frac{1}{2}$ to $\frac{3}{4}$ of an inch in thickness inside of the needles. Average galls have from 75 to 150 chambers and consequently a like number of needles, with from 1 to 10 or 12 lice to a chamber. Mr. Charles Jones counted the needles upon three large galls for me which ran as follows: 125, 170 and 215, an average of 170 needles to a gall. At the base there was an average of about 12, at the middle about 8 and near the tip about 5 young lice to a chamber. The largest number found in one cavity was 32.

Mr. George Weldon reared and counted the lice from five large-sized galls for me and they ran as follows: 463, 602, 750, 894, and 996.

The lice within the galls are light red in color, and their bodies are more or less covered with the white waxy secretion which occurs both in the form of a powder and as threads. It might seem that there would be no need of this secretion as a protection in the galls, but it is of the greatest importance here as the lice give off a large amount of liquid excretion, which would drown them if it was not prevented from touching their bodies by their covering which is not wet by the excretion. The cast skins also come into service here. Prof. Cooley has called attention to the fact that the lice within the galls of *Chermes abietis* retain their cast skins for a time, fastened to the posterior end of the body. If one of the galls is broken open when nearly mature, the cast skins may be seen filled as full as they can hold with the liquid excretions. They may be shaken out in the hand and examined, but are easily broken. They appear like plump white models (ghosts) of the lice that shed them.

About the 1st of July at Fort Collins the lice begin to transform to pupæ, and a few days later the most advanced galls begin to open. The earliest gall found with lice escaping in 1906 was taken by Mr. L. C. Bragg, July 3, on a tree exposed to the open sun on the south side of a building. On July 16, trees most exposed to the sun and not very thrifty had matured nearly all their galls and most of the lice had escaped. Large, more thrifty trees, and especially those that were shaded much of the time, still had most of their galls closed, and particularly upon branches near the ground. Galls broken open at this time expose the pupæ, which seem to pack every chamber full, and all their heads point outward from the centre toward the place of exit, ready to escape once more into the light of day as soon as the opening is made large enough. The pupæ cling to nearby leaves, usually those of the gall, and shed their skins. During the few hours that the lice stay upon the leaves the little white patches of cottony secretion begin to show like masses of mycelial threads of a fungus.

After a few hours of resting upon the galls the winged lice all leave and go, so far as I have been able to trace them, to the red fir (*Pseudotsuga mucronata*), where they settle upon the leaves, insert their beaks, and begin almost immediately to lay eggs, which accumulate in large piles beneath their wings. Each egg is anchored by a short silken thread attached to one end. The threads vary in length from those that are shorter than an egg to those that are more than twice that length. The threads also cling to the eggs and to one another after they are loosened from the leaf, so it is very difficult to separate them out from the general cluster (see Pl. IV, figs. B and D). The white

wax threads from the head, thorax and sides of the abdomen also grow very rapidly, so that, with the aid of the wings, both louse and eggs are almost completely hidden in two or three days. Egg laying proceeds very rapidly. From numerous counts made by the writer, and others made for me by Mr. G. P. Weldon, I extract the following: Seven large egg clusters, selected July 16 and 18, 1904, ran as follows in numbers of eggs: 96, 111, 127, 133, 136, 151, 155, an average of approximately 150. Seven medium egg clusters from leaves of red fir, where the lice had been located but 48 hours, gave counts as follows: 63, 66, 70, 74, 75, 88, and 104. Seven selected large egg clusters, where lice had been located only 48 hours, ran as follows: 90, 111, 126, 131, 133 and 150. When we consider the large size of these eggs as compared with the females that lay them, it seems to me this is a development of reproductive tissue that is simply marvelous. These winged lice seem never to change their location after they have once inserted their beaks and begun to lay eggs.

Occasionally one of these lice can be found feeding and laying eggs upon leaves of the blue (silver) spruce, but it is quite rare. By enclosing thousands of the lice in paper sacks upon twigs of this tree, I got enough to locate and lay eggs so as to get a few counts. The lice did not seem to be thrifty, however, and the number of eggs laid was smaller. Four lice located 48 hours on blue spruce deposited 16, 17, 19, and 36 eggs respectively. Seven of the largest patches where the lice had been settled 72 hours ran in numbers as follows: 33, 50, 53, 55, 74, 84, and 96; an average of about 64, or less than half the average number in large egg clusters upon red fir. On July 20, 1906, it required careful search to find one of these lice located upon blue spruce, while the red firs near them had one or more of the lice on nearly every leaf, and many leaves were loaded with five or six of them (Pl. II, fig. C and D).

Lice continue to emerge from the galls till about July 25, and all apparently are females.

The eggs laid by these winged females hatch in from six to seven days. Eggs laid July 12 began hatching July 18, and were all hatched on the 19th. The lice from these eggs are yellow at first, but soon become nearly black in color fringed with short wax threads similar to variety *coveni* (Pl. VI, figs. A, A¹). Many of the lice hatching at this time remain beneath the dead bodies of the winged females, which die soon after the eggs are laid, but most of them scatter about over the leaves and come to rest chiefly upon the older leaves near the bases of the small twigs. Here they insert their setæ and remain till spring

without growing perceptibly in size. These develop into stem-mothers upon the red fir the following spring and are probably the chief, but not the only, cause of the form described below as *coweni* occurring upon the red fir. It is also strongly probable that the stem-mothers for the two summer broods of *Chermes cooleyi* come in a similar manner from the winged females of variety *coweni* of the red fir that swarm upon the blue spruce in May, as described in my mention of the life history of that form below, though it is possible that the few females of *cooleyi* settling upon the blue spruce also give rise to stem-mothers the following spring, though in my attempts to follow these lice through the fall they have always perished. This brood of eggs laid by the winged females are practically all hatched by the end of July at Fort Collins.

Host Plants and Habitat.—I have found this species occurring in Colorado at Fort Collins, Greeley, Loveland, Boulder, Denver, Colorado Springs, Palmer Lake, Estes Park, and up Long's Peak and Pike's Peak to timber line. In the lower altitudes (from 4,000 to 8,000 feet) I have observed this gall chiefly upon blue spruce, but from 8,000 feet to timber line I have noticed it chiefly upon Engelmann spruce (*Picea engelmanni*). On August 15, 1903, I noted this gall as being very abundant on Engelmann spruce along the trail from Mill's Ranch to timber line on Long's Peak, and I have received the galls from the same locality sent by Mr. Enos Mills. The galls occur in small numbers to the limit of timber, but they become specially abundant three or four hundred feet lower down. The galls at timber line on August 15 were still closed, but a few hundred feet lower the lice were emerging. I have also received galls from the Sitcha spruce from the mountains of western Canada, sent me by Dr. James Fletcher, that seem undoubtedly to be of this species. This *Chermes* is surely a native of the Rocky Mountain region and, so far as I know, occurs only upon the trees mentioned. I find the galls most numerous in parks or lawns where the blue spruce and red fir are clustered together.

Stem-mother.—The stem-mother, in winter or early spring, is a grayish appearing object, about .6 mm. long by .3 mm. wide. The body of the louse is almost black, and the dark color shows through the white secretion which radiates in short stout threads about the margins of the body and rises in a crest down the median line of the back (Pl. III, fig. A). These hibernating lice are removed with some difficulty on account of the long setæ which are inserted deeply into the bark. After shedding the heavy winter coat the louse appears dark green in color, being lighter beneath and towards the posterior end of the abdomen, and becomes rusty brown later.

Adult Apterous Female (Pl. III, figs. B, C).—Fully grown examples measure 1 to 1.5 mm. in length by .8 to 1.2 mm. in width. The color is a dark rusty brown, and the entire dorsal surface is mottled with dark spots, representing the wax glands which occur upon all segments but the last. The arrangement of these glands is about as follows: On the head, nearly a continuous line of the gland pores on anterior margin, and two patches on a side near the hind margin; on the segments of the thorax and abdomen there are three glands on a side, but segments 5 to 8 of the abdomen have the patches more or less united, especially in the dorsal rows. The other glands of the dorsum have pores quite uniform in size and rather small (compare with var. *coweni*, Pl. VI, fig. B). On the ventral surface there is a pair of small patches upon the head caudad to the bases of the antennæ, and another pair of about the same size just in front of the middle coxæ. The antennæ (Pl. III, fig. F) are very small, about as long as the femora of the front pair of legs, or .14 mm., first and second joints short and stout and of about equal lengths, third nearly cylindrical and nearly twice as long as joints one and two combined, and with two tactile hairs at the tip. Legs (Pl. III, fig. G) short, rather weak, tarsi two-jointed, the basal one very short and appearing as a short piece on the under side.

Eggs.—The eggs are light amber yellow at first covered with a white powder. They are attached each by a silken thread and the whole mass clings together, so that it is difficult to separate a few from the general mass (Pl. I, fig. C). Before hatching, the eggs darken some and the eyes of the embryo show plainly through the shell as two dark spots. Length, .3 mm., width .17 mm.; good average size of egg-cluster, 2 mm.

Pupa.—The pupæ, when they first leave the galls, are of a uniform rusty brown color throughout, lightly dusted with a white powder. On leaving the gall, they walk out upon the leaves, come to rest, and in a short time the pupal skin splits over the head and thorax, and in a few minutes more the adult emerges. At first it is shining rufous in appearance with the wings deep green, which color is quite marked for some time after the wings are fully unfolded. This process takes about ten minutes. The costal nerve is light yellow from the first.

Winged Female (Pls. II, IV and XI).—The winged female is bright shining rufous at first, but by the time the wings are spread the eyes are black, and a few hours later the head and mesothorax are black also. The other portions gradually become darker, the abdomen retaining the rusty color longest. In about an hour after the pupal skin is shed the white secretion begins to show over the wax glands

and the louse soon flies away. The size varies much, the usual range being between 1.5 and 2 mm. in length. The *wings* are a little smoky with a large stigma that is slightly green and the costal nerve is yellow. The fore wing in a medium large louse is about 2.5 mm. long, or about 1.6 times the length of the body, with two simple discoidal veins, and one stigmal. Hind wing with one discoidal vein, length of the hind wing about equalling the length of the body. *Antennæ* dusky, five-jointed, about three-fourths as long as the greatest transverse diameter of the head. Joints 1 and 2 short, stout, cylindrical and about equal in length; joint 1 rather smooth, but the remaining ones with impressed transverse lines or wrinkles. Joints 3 to 5 subequal in length, with joint 3 usually a little stouter and more conical; joints 4 and 5 rather slender, not especially enlarged at distal end, nor swollen for the transverse sensoria, of which there is one to each of the three terminal joints; fifth joint with two short hairs at distal end. The arrangement of glands is shown in Pl. IV, fig. A, and is about as follows: On the head two large transverse patches on anterior margin nearly coalescing, and a long narrow patch extending across the hind margin which may be divided at the median line; on the prothorax a long narrow patch occupying the entire lateral margin upon either side, and two long narrow patches along the hind margin nearly meeting at the middle line, and nearly or quite meeting the posterior ends of the lateral patches that are usually reflected mesad a short distance along the hind margin of the segment; mesothorax with two small patches mesally located near the hind margin, in line with the two middle rows of glands upon the metathorax and abdomen; metathorax with the middle pair of glands only; abdomen with three rows of glands on either side over the first seven segments, except that the middle row is lacking on segments one and two. The lateral rows have the larger patches, and these rows are continued upon the eighth segment; the glands of the middle rows are smallest, and all the four dorsal rows become smaller as they recede from the thorax. The number of gland patches is not constant and the weaker ones are often wanting, and the larger ones sometimes coalesce.

Chermes cooleyi var. *coweni* n. v.

This louse has been injuriously abundant on small trees of red fir in lawns and parks of northeastern Colorado for a number of years. I first observed it on trees standing upon the campus of the Colorado State Agricultural College, where it has been abundant for ten years past at least. A brief description of the winged female was given in Bulletin 31, p. 115, of the Colorado Experiment Station, by Mr. J. H.

Cowen. I have also mentioned this louse on p. 17 of the 1901 report of the same station. This form varies enough from *cooleyi* to be considered a distinct species; but as these two seem to owe their differences to an alternation of food plants, I have thought best to consider the form upon red fir a variety of *cooleyi*.

Life History.—The winter is spent as minute black lice, each being surrounded with a halo of white waxy threads and resting upon the upper surface of a leaf. They often occur in a line along the median groove. A few warm days about the last week in March or the first week in April cause the lice to grow, excrete drops of nectar, and burst the old larval skin. This first spring moult takes place at Fort Collins about April 1st. The hibernating form is shown on Pls. V and VI, figs. A and A¹. As soon as the old skin has been cast, little patches of white secretion begin to appear along the dorsal surface, and in a few days more the entire body will be hidden by long curled threads of this material. About the 20th of April egg-laying begins, though not all of the lice develop together, and the time of the first egg-laying varies with the earliness of the season. From twenty-five to forty light yellow eggs are laid by each louse, and these hatch freely just as the new leaves begin to open at the ends of the twigs, and nearly all are hatched by the last of May. The lice migrate on to the new growths, insert their setæ into the tender leaves and begin to feed and grow, and apparently they never change their location afterwards. This first brood from eggs for the year is dimorphic, in that about one-half remain wingless like the preceding generation, while the other half develop wings. The adults of the alate form appear about June 10; the wingless ones lay eggs like their predecessors, and the young hatching from them, for the most part, insert their setæ in the leaves, take on a dark color, secrete a little of the white waxy material about themselves and upon their backs, and so remain until the following spring before growing perceptibly in size, and then become stem-mothers; but those that acquire wings all leave the red fir and, so far as I have been able to trace them, settle upon the leaves of the blue spruce (*Picea parryana*), though it is probable that they do settle on Engelmann spruce as well. Some of the apterous females continue to develop and lay eggs, especially in shady places and upon tender new leaves, until late in July or even longer; but for the most part development closes with the young hatching from the second brood of eggs for the year, making two full broods annually besides the partial broods.

The winged examples that migrate to the blue spruce settle upon the needles, secrete a large mass of cottony threads, deposit a patch

of 30 to 40 eggs beneath their wings and die. The eggs hatch in about a week and the young remain on the leaves without developing until spring, as in case of most of the young from the second brood of eggs by the apterous individuals.

When abundant, early in the summer, the little snowy white patches concealing the apterous females and their young are so numerous as to attract attention to the foliage (Pl. V, figs. B, C and D). When the first brood from eggs for the year hatch and settle upon the new leaves, the latter often become crooked and disorted in shape and yellow in color (Pl. V, fig. C). I do not think I have ever seen a tree killed by this louse, but they are often made to look very unthrifty and sickly in color of foliage.

Hibernating Female.—The hibernating female, or stem-mother, grows very little if at all, after hatching from the egg the previous June or July, until the warm days of spring. The color, which seems black, is really a very dark green and the body is fringed all round with short white threads of waxy secretion, and down the middle of the back there is often a crest of the same threads, though these are not always present, and the entire dorsal surface is finely dusted with wax particles that glisten with a silvery white light. The setæ are considerably longer than the body and are inserted in the leaves, through the fall and winter (Pl. VI, figs. A and A¹). The length before spring development varies little from .4 of a millimeter. The antenna is three-jointed and little exceeds a front tibiae in length, first and second joints short and stout and about equal in length, and the third joint fully one-half longer than joints 1 and 2 together, and quite scabrous in appearance due to transverse impressed lines, and with about four hairs at the tip. About the middle of April the liquid excretion is being given off freely, and the waxy secretions now begin to show plainly as transverse rows of white spots across the dorsal surface (Pl. V, figs. A, A.). When the winter skin is shed, the louse changes to a rusty brown color, darker towards the head. Adult specimens measure from .8 to 1.2 millimeters in length and from .6 to .9 mm. in greatest breadth. The antenna is still short, three-jointed, the third joint rather longer than joints 1 and 2 combined, and the whole length about .09 mm. (Pl. VI, fig. E).

The *wax glands* are arranged about as in *coolcyi*, but the pores are larger and fewer in number, at least for the glands anterior to the fourth abdominal segment (Pl. VI, figs. B and C). On the head there are three gland patches on either side, and then there are three rows on a side over the succeeding body segments to the sixth abdominal; on

the seventh the median glands unite, reducing the number to five, and upon the eighth segment but three occur. A pair of rather large glands occur between the antennæ below, and there is a small one on either side in front of the middle coxæ. The rostrum is short and stout, with joints 1 and 2 subequal in length.

Pupa (Pl. VI, fig. F).—Length, .7 to 1 mm. Color light to a dull reddish brown, becoming darker as the time for moulting approaches. From the front of the head are two short, broad, outwardly curved pencils of white secretion, one on either side of the median line. The body is also more or less whitened by a covering of fine white powder, but there are no long waxy filaments; head, thorax and wing pads a little darker than the remainder of the body. Dark spots marking the presence of developing wax glands may be seen as follows: Upon the front of the head two large ones, and back of these two others of smaller size close to the hind margin; on the prothorax a very large lateral gland upon either side, and mesad of each of these four small ones; mesothorax with one lateral and one submedian spot on either side, both small; metathorax with three spots on each side in a line near the hind margin. On the abdomen there are six longitudinal rows extending over the first five segments, and the lateral rows over two or three segments more.

Winged Female (Pl. VII, fig. A).—Length, commonly .7 to 1.2 mm. Color reddish brown with head and thorax black or blackish, legs and antennæ a little dusky. Anterior wings 1.4 to 1.8 mm. in length, slightly smoky, venation normal; posterior wings without transverse nervure. After locating upon the blue spruces the body soon becomes nearly buried in a mass of white waxy threads, as in the case of *cooleyi*. Antenna nearly as long as the greatest width of the head (about .25 mm.), joints 1 and 2 short and subequal, joints 3 and 4 also subequal with the fourth a trifle the longer, fifth joint slightly longer than the fourth, joints 3, 4 and 5 deeply transversely marked with impressed lines and much enlarged toward the distal ends, and each with a transverse sensorium of moderate size, all the joints robust (Pl. VII, fig. B). Legs dusky brown and rather stout. Glands arranged about as follows: a large one on the front of the head on either side at the base of the antenna, and on the posterior margin of the head, close to the median line, another pair of smaller glands; on the prothorax, a large gland patch on the posterior lateral margin that extends a short distance along the hind margin, and a smaller patch on the hind margin near the median line upon either side. Upon the mesathorax, one pair of large submedian glands, and upon the

abdomen there are three longitudinal rows upon either side, the middle row being quite small and occurring only upon segments 2 to 6. The inner rows occur upon segments 1 to 6, and the lateral rows upon segments 1 to 8. In a large series considerable variation will be found in the number of these glands, as some of the smaller patches often are wanting. I have found this form developing on the red fir only.

The distinguishing characters are the short stout beak, the small size and large pores of the dorsal glands, and the large size of the gland patches between the antennæ in the apterous form and the robust antenna and small sensoria of the winged form.

***Chermes montanus* n. sp.**

On July 20, 1906, Mr. Harley F. Wilson collected galls of what seems undoubtedly to be a new species of *Chermes* at Victor, Colorado, at an altitude of about 9,000 feet. The inmates had already left some of the galls and from others they were just emerging. The writer visited the locality August 5 following, to determine what spruces these galls occur upon, and found them upon blue spruce only. On the same trees with them were old and new galls of *Chermes cooleyi*.

The galls (Pl. VII, fig. C) are cone-shaped, from three-fourths to more than one inch in length, and are a modified development of the new growth at the tip of a twig. Each needle, instead of thickening as in case of the galls of *cooleyi*, broadens in the middle and becomes concave on the inner or axillary surface. The broadened portion may include nearly the entire needle at the base of the gall, but towards the tip the broadened part extends a less distance from the base. The stem from which the needles arise is little if any swollen. The lice cause the death of the end of the twig, and as the tissue dies and begins to dry the modified leaves open so that the lice readily escape. Because of the loose structure of these galls *Syrphus* larvæ prey freely upon the lice.

Pupa.—The pupæ seem darker in color than those of *cooleyi*, but otherwise I cannot see that they are specially different.

Winged Adult.—When the pupal skin is first cast, the wing pads are yellow in color instead of green as in *cooleyi*, and the costal and subcostal nerves retain the same color after the wings unfold. The length of the body varies between 1.5 and 2.2 millimeters. The color is a reddish brown, abdomen rust brown, antennæ and legs dusky, wings normal, hind wings with one cross vein, and slightly smoky. Antennæ (Pl. XI, fig. A) five-jointed, joints rather stout and somewhat more enlarged at distal ends than in *cooleyi*, the striations

upon joints 3 to 5 quite strongly curved, especially on joints 4 and 5, the convexity being towards the distal ends of the joints. Joints 1 and 2 short, stout, cylindrical; joint 3 a little longer than 4, and joint 5 a little longer than 3; joints 3 to 5 each with a very large sensorium; on joint 3 it extends fully one-third the length of the joint along the ventral side, in joints 4 and 5 the sensoria extend fully one-half the length of the joints; there are almost no hairs except for a cluster of four or five at the tip of the last segment. The antennal characters alone easily separate this species from all others mentioned in this paper. The legs are as distinctive as the antennæ, being much stouter than those of any other species I have studied (Pl. XI, fig. B).

The *wax glands* that are so conspicuous in cleared specimens of other species of *Chermes* are absent or faintly distinguished in the winged females of this species. The galls of this species are very distinct from those of any other *Chermes* known to me.

Eggs, young, and wingless females of this species have not been studied.

Chermes similis n. sp. (Plate VII, figs. D, D', E, E'.)

On the visit to Victor, Colorado, August 5, I collected from trees bearing galls of *Chermes cooleyi* another gall very similar in appearance. Winged lice were issuing from them, as they were also from galls of *cooleyi*.

Galls.—The galls I collected were rather short and thick for those of *cooleyi*; they were in every case terminal upon the twigs, and they are produced by the broadening and thickening of the basal portion of the needles, but not at the extreme base as in *cooleyi*, see Pl. VII, figs. D and E. At the point of attachment the needle is about normal in size, but an abrupt thickening and broadening takes place about three or four millimeters from the twig. Each needle is separate from its neighbors, however, and may be removed without the tearing of any tissue except a small spot about one millimeter across at the point of attachment, so that in place of a number of separate chambers, as in the galls of *cooleyi*, the lice live in open spaces which pass into one another about the bases of the needles. The casual observer would not be likely to notice any difference between this gall and that of *Chermes cooleyi*.

The pupæ, as in *cooleyi*, are quite heavily covered with white powder when ready to emerge.

Apterous females and their egg-clusters were also found in some of the galls, but there was no way to make certain that they were of the same species.

The looseness of structure in the galls allowed the attacks of *Syrphus* larvæ which were very common.

Winged Female.—Color as in *cooleyi*; length from 1.3 to 2 millimeters; wings a little smoky, especially along the veins; venation normal, one transverse vein in hind wing very distinct. *Wax glands* of abdomen are arranged as follows: The lateral rows with well-developed glands on the first six segments; the two dorsal rows well developed on segments 1 to 6; the middle row on either side begins on segment 3 and ends upon segment 6. The antenna in this species is very similar to that of *montanus*. Segments 1 and 2 are short and cylindrical, segments 3, 4 and 5 are in the proportion of 22, 26, and 25 respectively, segments 3, 4 and 5 are provided each with a very large sensorium similar to those found upon the antenna of *montanus*. The transverse striations upon the segments run in nearly straight transverse lines instead of curved lines, as in the case of *montanus*. This species is easily separated from *montanus* by the presence of well-developed wax glands upon the abdomen, and the more slender legs.

I supplied the breeding cage where this louse was emerging with fresh twigs of red fir and blue spruce. The lice began at once to locate upon the needles of the blue spruce and to lay eggs rapidly, but none located upon the needles of the red fir.

The galls were all taken from blue spruce trees and were considerably less numerous than those of *Chermes cooleyi*. Altitude 9,000 feet.

***Chermes coloradensis* n. sp.** (Plates VIII, IX and X.)

This species was first noticed by the writer upon the needles of Bull or yellow pine (*Pinus scopulorum*) growing upon the campus of the Colorado State Agricultural College in the spring of 1897. Its presence has been noticed in some numbers every year since. Some years the needles and the new growths have been fairly whitened with its cottony secretions during late spring and summer (see Pl. VIII), while in other years the lice have barely been able to survive in small numbers, as their insect enemies are many and active. The writer figured this louse upon pine needles in Plate I of *Fourteenth Annual Report of the Colo. Agr. Exp. Station*, 1901.

Habitat and Host Plants.—I have found this louse common upon Bull pines occurring upon the foothills of northeastern Colorado and in the city parks of Colorado Springs and Denver. In 1905 I found it common upon this pine in the vicinity of Palmer Lake. During the last week of June, 1906, Prof. T. D. A. Cockerell sent me infested pine needles from Florissant, Colorado, that were taken at an altitude of 8,000 feet, and I have on several occasions taken what seems to be the same species upon Lodge Pole pine (*Pinus murrayana*) growing upon

the campus of the Colorado Agricultural College at Fort Collins. During June of 1905 and of 1906 I also took apterous females with their egg-masses from leaves and young cones of Piñon pine (*Pinus edulis*) at Salida, Colorado, at an elevation of 9,000 feet, which seem to be of this species.

In some instances the lice have been abundant enough to stunt and weaken small trees, but I can hardly consider this insect a serious pest upon the pines at the present time, except as it frequently mars the appearance of the foliage of small trees in parks and about private residences.

Life History.—There seems to be no small hibernating form of this louse, as of the spruce-infesting species mentioned in this paper. Wingless lice in various stages of development pass the winter down among the flower buds, between the needles near their bases, or in other protected places. Examples taken February 27 ranged between .4 and .8 mm. in length. I have found the hibernating lice in considerable numbers spending the winter beneath the scales of *Chionaspis pinifoliae*. This habit of spending the winter in varying stages of development and in more protected places probably accounts for this species getting the start of others in its development in the spring. At Fort Collins, the little white patches of secretion begin to show about the first week of April among the buds and between the needles (see Pl. VIII, fig. A), and by about the 10th of the month the first spring eggs are being laid. By the 5th of May it is common to find from 20 to 40 eggs to a female and the first young hatching. About one-half of the lice from this brood of eggs become winged, and the other half remain wingless and go on producing other generations of wingless lice and eggs until fall, a habit similar to var. *cowni* on red fir. The winged individuals all seem to be females and all leave the pines, but I have not been able to trace them to their alternate food plant, which I presume to be one of the spruces. The winged form begins leaving the trees about May 20, at which time the first brood of wingless females from eggs for the year are beginning to deposit eggs for another generation of apterous individuals, which begin to deposit their eggs about June 10. The winged form continues to appear for about ten days. I have seen the apterous females and their eggs in all stages of development from April 9 to October 22, but the number of generations that the lice pass through in a year I have not determined.

The number of eggs laid by a single individual is not large, about 30 or 40, but the precise number is difficult to obtain as the first eggs laid hatch before the last from the same females are deposited. All are

attached by threads to the surface upon which the female rests. I have had a female lay 9 eggs in 24 hours.

The individuals of the first brood that are to become winged secrete a conspicuous fringe of white wax threads about the borders of the head and prothorax in the pupa stage (Pl. IX, fig. D), which, with the longer antennæ, readily separate them from the apterous form.

Apterous Female (Pls. IX and X).—The length of laying individuals varies between .5 and 1.2 mm.; the color is a rusty brown, rather light over the abdomen and darker upon thorax and head where the color may be a slaty brown. The antennæ are minute, about .06 mm. long, three-jointed, joints 1 and 2 short and cylindrical and about equal in length, joint 3 distinctly longer than joints 1 or 2. Legs small and weak, femora about twice as long as thick, tibiæ equaling femora in length, tarsus two-jointed, the first joint appearing as a wedge-shaped piece with the broad end below; three clear spots upon either side of the head in the position for compound eyes which may function as ocelli. The *wax glands* (Pl. IX, figs. A, B, C) upon the dorsum of the adult seem quite constant and are arranged about as follows: Upon the head and prothorax, which are so united as to appear as one piece, there are, upon either side of the median line, a longitudinal row of four glands and outside of these another row of three, and still outside of these, and located near the posterior lateral angles of the prothorax, are three more small gland areas. The mesothorax has one transverse row of from eight to ten of these glands; the metathorax and first abdominal segment each have a transverse row of eight, but those upon the abdominal segments are small over the middle dorsal portion and may be largely missing; the second abdominal segment lacks two or four of the middle glands, leaving a row of four or six, and segments 3 and 4 usually have but four glands each, one upon the lateral margin and one near it a little mesad, and the glands upon the lateral margins are continued upon two or three succeeding segments. Upon the ventral surface there is a small gland near the base of each antenna and one (which may be separated into two parts) in front of each coxa. The marginal gland patches show upon the ventral as well as upon the dorsal surface, and in some specimens small glands may be detected upon the abdominal segments just inside the spiracles (Pl. IX, fig. B).

The *eggs* are light yellow in color and are entirely hidden from view by the long wax threads secreted chiefly from the head and thorax of the female; they vary little from .32 mm. long by .17 mm. in width, and each egg is anchored from one end by a short thread. As the eggs

advance in age they become darker in color and exhibit two dark eye-spots of the developing embryo.

Pupa (Pl. IX, fig. D).—Length varying but little from 1 mm. Color of abdomen a light rusty brown, head and thorax blackish, wing pads and legs dusky brown. As the time for moulting approaches a heavy fringe of short stout wax threads or scales develop about the margins of the head and prothorax and along the median dorsal line of the cephalothoracic plate, and about six small glands on either side of the cephalothoracic region push out long slender dividing threads of the same material. Near the time for moulting the body becomes covered with a white powder and the wax glands posterior to the prothorax are indicated by little white spots of secretion, but no threads are developed. The lateral rows of glands may be traced upon the abdomen to about the sixth segment, while the middle rows upon the dorsum usually end upon the second or third segment.

Winged Female (Pl. X, figs. A and B).—Color a rusty brown throughout just after shedding the pupal skin, but the head and thorax soon become nearly black in color. A measurement of thirteen examples gave lengths varying between .85 and 1.15 mm., the variation being due chiefly to the different lengths of the abdomen, as in some it was fully extended and in others the terminal segments were contracted. The wings are a little smoky in appearance, due to a great number of curved black dashes that are rather closely set over the entire surface. The wings vary little in length, the anterior pair measuring but little either side of 1.5 mm.; venation normal for this genus, the subcostal nerve strong and, with its large lanceolate stigma, smoky brown in color. There are two simple transverse nervures and the stigmal nerve is long and nearly straight, ending in the center of the apex of the wing.

The posterior wings are lanceolate in form, a little more than one-half the length of the front wings (ratio 1 to 1.7), and have two or three chitinous hooks on the costal margin. The transverse nerve is wanting (see Pl. X, fig. A).

Antenna dusky brown, five-jointed and .26 mm. in length; the terminal joint is slightly the longest (.067 mm.), joints 3 and 4 subequal (.06 mm.), the first and second joints short and cylindrical and of about the same diameter as the others; joints 3, 4 and 5 fusiform and imbricated; the distal ends of 3 and 4 truncated, but the fifth joint tapering gradually to the apex. Joints 3, 4 and 5 have each a large oval sensorium on the ventral side. There are about five hairs at the apex of the terminal segment and a

very few scattering ones on the other joints. *Ocelli* three in number, one just above each compound eye, and one median in position upon the front above the insertion of the antennæ.

Legs dusky brown, tarsi two-jointed, the basal joint very short, tibiæ with prominent sucker at distal end, the use of which is readily seen by allowing one of the winged lice to walk over a glass slip under a microscope.

The *wax glands* are fewer in number over the head and thorax than in the apterous form; on the anterior margin are two that occupy nearly the whole distance from eye to eye, and there are two similar patches on the hind margin; there is also a long narrow patch upon either side along the hind margin, and in front of either of these is another very small patch. On the mesothorax occur the usual two patches near the median line next to the scutum, and upon the meta-thorax two large patches in line with the two inner rows upon the abdomen. Over the abdomen there are three longitudinal rows upon either side extending over about six segments. The patches are largest in the marginal and the middle rows, and the latter sometimes coalesce on the proximal segments. For arrangement of the glands see Plate X, fig. A.

Young Louse.—When first hatched the young are pale yellow in color and about one-third millimeter in length. The eyes are dark, the antenna three-jointed and about two-sevenths the length of the body, the third joint about one-third longer than joints 1 and 2 together, and the first two joints are subequal in length. Each tarsus has two glandular hairs. The young of this species can hardly be distinguished from the young of *cooleyi* shown at Plate III, fig. E.

***Chermes pinicorticis* Fitch.**

I have found this species abundant upon a few trees of *Pinus sylvestris* in City Park, Denver, but have seen it nowhere else in Colorado. The cottony covered apterous females were numerous enough upon the smaller limbs of the trees to give them a distinctly whitened mouldy appearance. An excellent paper upon this species, containing a bibliography by Mr. E. L. Stormont, was published in the Appendix to the *Twentieth Report of the State Entomologist of Illinois*.

Natural Enemies.—Most of the common plant louse enemies attack genus *Chermes*, but I have never found one of these lice attacked by internal parasites. *Chrysopa* species seem to attack them very little, but *Syrphus* and *Coccinellid* larvæ are great destroyers of these lice when exposed upon the surface of plants, the cottony secretion being apparently no hindrance. I have never found *Chermes cooleyi* dis-

turbed within the gall chambers, but *Syrphus* larvæ at least attack *Chermes similis* and *Chermes montanus* before they escape from their galls. The most destructive enemies of the *Chermes* that infest red fir and pine in the neighborhood of Fort Collins is the yellow and black lady-beetle, *Harmonia picta*, shown in Plate XI, figs. D, E, F.

I wish especially to express my obligations to Miss Miriam A. Palmer for her accurate and painstaking work in the preparation of the pen drawings illustrating this paper.

If in any case the measurements as given in the plates do not fully correspond with measurements as given in the text, the latter is to be taken as correct.

EXPLANATION OF PLATES I-XI.

PLATE I.—*Chermes cooleyi*, new species.—A, twig of blue spruce showing three egg masses, natural size; B and C, egg masses with waxy secretion removed, $\times 8$ times; D, two galls on a twig cut to show interior cavities, $\times \frac{1}{2}$. (Photos by author.)

PLATE II.—*Chermes cooleyi*, new species.—A, two full-grown galls, natural size; B, needles from full-grown galls showing enlarged bases; C', winged female, beneath and at right of D winged female, ovipositing upon leaves of red fir; D, an egg mass with female removed; E, gall cut to show that each gall chamber has a complete wall shutting it off from all other chambers. Figures of lice much enlarged. (Photos by author.)

PLATE III.—*Chermes cooleyi*, new species.—A, hibernating stem-mother in winter, $\times 85$ times; B and C, adult stem-mothers, dorsal and ventral views showing wax glands, etc., $\times 65$ diameters; D, eggs attached by threads, $\times 20$ diameters; E, young from first brood of eggs, $\times 125$ diameters; F, antenna of adult, $\times 240$ diameters; G, leg of adult, $\times 120$ diameters; H, normal leaf, and I, leaves from gall, all enlarged three times. (Miriam A. Palmer, artist.)

PLATE IV.—*Chermes cooleyi*, new species.—A, winged female, $\times 26$ diameters, showing wax glands of dorsal surface; B, the same with wings closed laying eggs, $\times 20$ diameters; C, antenna of same, $\times 200$ diameters; D, egg mass of same, $\times 30$ diameters. (Miriam A. Palmer, artist.)

PLATE V.—*Chermes cooleyi* var. *coweni*, new variety.—A and A, hibernating stem-mothers beginning to grow in spring, $\times 20$ diameters; B, sprig of red fir showing white egg masses, slightly reduced; C, sprig of red fir showing curled leaves of new growth where young lice are locating, natural size; D, egg clusters of preceding, $\times 15$ diameters. (Photos by author.)

PLATE VI.—*Chermes cooleyi* var. *coweni*, new variety.—A, apterous cottony covered female and her hibernating young, the last of June, $\times 8$ diameters; A', hibernating young lacking dorsal wax threads, $\times 50$ diameters; B and C, dorsal and ventral views of adult hibernating female showing wax glands, etc., $\times 45$ diameters; D, leg $\times 60$ diameters; E, antenna, $\times 240$ diameters; F, pupa, $\times 40$ diameters. (Miriam A. Palmer, artist.)

PLATE VII.—*Chermes cooleyi* var. *coveni*, new variety.—A, winged female, $\times 40$ diameters; B, antenna of same, $\times 240$ diameters; C, gall of *Chermes montanus*, n. sp., $\times 2$ diameters.

Chermes similis, new species.—D and D¹, E and E¹, two views of two leaves from a gall of this species, the former from near the base and the latter from near the tip, showing the difference in their development; $\times 2$ times. (Miriam A. Palmer, artist.)

PLATE VIII.—*Chermes coloradensis*, new species.—A, lice between the needles during winter and early spring; B, attacking the new growth a little later; C and D, cottony masses covering the wingless females and their eggs, taken during June. A, B and C enlarged $3\frac{1}{2}$, D 4 times. (Photos by author.)

PLATE IX.—*Chermes coloradensis*, new species.—A and B, apterous females taken during May, showing dorsal and ventral surfaces with arrangement of glands; C, dorsal surface of wingless female taken October 22; D, pupa taken June 22; e, anterior leg of A, $\times 120$; f, antenna of the same, $\times 200$. A and B are enlarged 50 times, C 90 times, and D 40 times. (Miriam A. Palmer, artist.)

PLATE X.—*Chermes coloradensis*, new species.—A, winged female showing wax glands, etc., enlarged 50 times; B, antenna of preceding, $\times 200$ times; C, half-grown apterous female taken October 22, showing long curved pencils of secretion and drop of excretion, $\times 40$ times. (Miriam A. Palmer, artist.)

PLATE XI.—A, antenna of *Chermes montanus*, new species, $\times 200$ diameters; B, fore leg of *C. montanus*, $\times 50$ diameters; C, leg of *C. cooleyi*, $\times 50$ diameters; D, E, and F, larva, pupa and adult of *Harmonia picta*, much enlarged. (Miriam A. Palmer, artist.)